MARTIAN EXOBIOLOGY IN THE POST-ALH 84001 ERA: SOME KEY ISSUES. J. F. Kerridge, Box 0317, Department of Chemistry, University of California–San Deigo, La Jolla CA 92093, USA.

Announcement of apparent evidence for an ancient martian biota in the ALH 84001 meteorite [1] has greatly expanded a longstanding discussion about the plausibility and detectability of life on early Mars [2]. The continuing debate over the ALH 84001 findings illustrates several key issues of relevance to future searches for martian biology.

Criteria for Biogenicity: McKay et al. [1] recognized correctly that multiple lines of evidence will be needed for a successful identification of life on Mars. Unfortunately, all of their proposed biomarkers are sufficiently weak that the mere fact of their multiplicity cannot create a positive identification. However, this failure does not negate the multiple-biomarker concept, which will be mandatory in future studies.

Importance of Controls: The study by McKay et al. [1] incorporated numerous control experiments but nonetheless these fell short of rigorously excluding non-biological artefacts. Specifically, in several cases the purpose of the controls was apparently more to show that an observed phenomenon could have a biological origin, rather than to demonstrate that it could not have a non-biological origin. Needless to say, with such an important issue at stake, the latter, more restrictive approach should have been used, and must be used in future studies.

Paleotemperatures: Early estimates of low- (20°–80°C) [3] and high-formation temperatures (>600°C) [4] for the ALH 84001 carbonates appear to be compromised by lack of isotopic and chemical equilibrium within those carbonates [5]. More-recent studies have yielded temperatures of <300°C, from O-isotope distributions [5], and <325°C, based on persistence of natural remanent magnetization in the host pyroxene [6]. Disequilibrium probably renders the former estimate suspect also, but neither estimate is immediately relevant to the issue of possible martian biology; the maximum known temperature for life on Earth is 113°C [7], and there are few grounds for supposing that martian organisms would have been immune to the consequences of thermodynamics. (Furthermore, the very concept of formation temperature may need to be revisited in light of evidence that magnetite inclusions in the carbonate apparently formed by vapor condensation [8].) Development of a robust paleothermometer for use in martian hydrothermal, or other aqueously mineralised lithologies, is clearly necessary to support future searches for life on Mars.

Implications of Negative Conclusions: It is important to realise that, when the claim for evidence of extinct life in ALH 84001 is finally recognised to be incorrect, the scientific case for the active exobiological exploration of Mars will remain solid [2]. Furthermore, the intense public interest in the findings of McKay et al. [1] has established beyond any doubt that the search for life on Mars is an appropriate activity for a publicly funded agency. It should also be noted that a finding that life did not emerge on Mars would be of comparable scientific importance to a discovery of former martian life, exciting though the latter would be.

References: [1] McKay D. S. et al. (1996) *Science, 273,* 924. [2] Kerridge J. F. et al. (1995) NASA SP-530. [3] Romanek C. S. et al (1994) *Nature, 372,* 655. [4] Harvey R. P. and McSween H. Y. (1996) *Nature, 382,* 49. [5] Valley J. W. et al. [1997] *Science, 275,* 1633. [6] Kirschvink J. L. et al. [1997] *Science, 275,* 1629. [7] Stetter K. (1996) *FEMS Microbiol.Rev., 18,* 149. [8] Bradley J. P. et al. [1996] *GCA, 60,* 5149.